National Park Service
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Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring at Tallgrass Prairie National Preserve

Year 2 (2010)

Natural Resource Technical Report NPS/HTLN/NRTR—2011/476

ON THE COVER
Autumnal prairies at Tallgrass Prairie National Preserve in the Flint Hills of Kansas. NPS file phto.

Invasive Exotic Plant Monitoring at Tallgrass Prairie National Preserve

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August 2011

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Bell, J. C., C. C. Young, L. W. Morrison, and C. S. Gross. 2011. Invasive exotic plant monitoring at Tallgrass Prairie National Preserve: Year 2 (2010). Natural Resource Technical Report NPS/HTLN/NRTR—2011/476. National Park Service, Fort Collins, Colorado.

NPS 031/109140, August 2011

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Executive Summary

In 2006 and 2010, a cumulative total of 19 invasive exotic plant taxa were documented in Tallgrass Prairie National Preserve. Most plants were not widespread as 71.4% and 57.1% of the invasive plants found during both surveys occurred in less than 5% of transects in 2006 and 2010, respectively. Only buffalobur nightshade (a native weed) and Japanese brome, which are not considered highly invasive, exhibited high frequencies (>20%). Based on the minimum cover estimates for all species encountered in each survey, total invasive plant cover in the park did not change between years with at least 120.6 acres and 126.3 acres in 2006 and 2010, respectively. Smooth brome accounted for the great majority of this cover with minimum estimates indicating at least 83 acres in the park in 2010. Maximum cover of only seven of 19 invasive exotic plants exceeded 10 acres. This included all five grasses identified in the survey and two forbs: Japanese brome, Johnsongrass, Kentucky bluegrass, smooth brome, tall fescue, buffalobur nightshade, and spreading hedgeparsley. Sweetclover increased in abundance and frequency between 2006 and 2010 in restored prairies and pastures adjacent to Fox Creek. While the abundance of bull thistle and Eastern red cedar apparently increased, all other species were similarly abundant in both surveys. We attributed finding five plants in only one survey and the increases in the abundance or frequency of Japanese brome and spreading hedgeparsley to observer errors, which we will improve in subsequent surveys. The information presented in this report may be used to plan management activities leading to control of exotic plants and the accomplishment of GPRA goal IA1.

Introduction

An invasive exotic plant is a plant species that is not native to an area and is presumed to pose environmental harm to native plant populations or communities. In general, invasive exotic plant species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss as threats to global biodiversity (Wilcove et al. 1998). Prevention and early detection are the principal strategies for successful invasive exotic plant management. Invasive plants often undergo a lag period between introduction and subsequent colonization of new areas. Managers can take advantage of monitoring efforts to detect invasive exotic species early and initiate control actions before populations become well established. (Paragraph based on Welch and Geissler 2007).

The native and restored tallgrass prairies of Tallgrass Prairie National Preserve are significant cultural and natural resources within the Flint Hills. In general, invasive plants occupy relatively little area within the grazed and burned prairie. Rather, the majority of invasive plants in the park are associated with areas that were farmed and later improved as pasture or restored to prairie (Young et al. 2009). To prevent further invasion and to maintain restored prairies, Tallgrass Prairie National Preserve controls invasive exotic plants species using herbicide and mechanical methods, such as cutting and haying.

Methods

Watch lists

Invasive exotic plant species on three watch lists were sought during monitoring (Table 1). Plants designated as high priority invasive species (Young et al. 2007a) and not known to occur on the park per NRInfo, NPSpecies Application (Natural Resource Information Portal) constitute the early detection watch list. Designated invasive exotic plants known to occur on the park per NPSpecies constitute the park-established watch list. Invasive exotic plants from the park-based watch list included plants selected by park managers or network staff that were not designated as invasive in the protocol, but may not have been included due to incomplete information in NPSpecies (i.e., not documented) or USDA Plants databases (i.e., state distribution information inaccurate) or due to differing opinions regarding Heartland Network designation of a plant as a high priority. The park-based watchlist for Tallgrass Prairie National Preserve included two native species, buffalobur nightshade and Eastern redcedar, which may rapidly colonize disturbed sites. While aquatic species are listed on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented occasionally.

Field methods

Invasive exotic plant species on designated watch lists (Table 1) were sought in high priority areas on Tallgrass Prairie National Preserve (Figure 1). Dan Tenaglia used a Thales GPS unit to conduct the first survey from September 19-29, 2006. Using a Magellan MobileMapper® 6 GPS unit with real-time differential correction and ArcPad® 7.1 software, Justin Thomas of the Institute of Botanical Training conducted the second survey from August 16-September 5, 2010. Surveys were conducted along 400-m line transects to identify invasive exotic plants in an approximately 3- to 12-m belt. Coarse cover values (0=0, 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2) were attributed to each

species for each transect. A total of 301 transects were surveyed at Tallgrass Prairie National Preserve. Of these, 274 transects were 400 m in length, while 27 were clipped to the park boundary. In 2006, the observer had discretion to search a larger belt if feasible, to search additional areas up to a 200 m perpendicular distance from a transect, to target locations likely to support exotic plants (e.g., field edges, roads), and to circumvent extremely difficult or hazardous terrain when needed. However, in most cases, the observer maintained the established line transect. In 2010 observations were strictly limited to the 3- to 12-m belt.

Taxonomic caveats

Caveats in the identification of four taxa were required. An annual brome was identified as bald brome (*Bromus racemosus*) in 2006 and as Japanese brome (*Bromus japonicus*) in 2010. These were likely the same species which we currently have best identified as Japanese brome. A species was also identified as Japanese hedgeparsley (*Torilis japonica)* in 2006 and as spreading hedgeparsley (*Torilis arvensis)* in 2010. Based on distribution maps (USDA Plants database 2011), the correct identification is believed to be spreading hedgeparsley. A cattail was identified as narrowleaf cattail (*T. angustifolia*) in 2006 and as *Typha X glauca* in 2010. Because *Typha X glauca* is a hybrid of narrowleaf cattail, the cattail was documented in this report as *T. angustifolia/X glauca.* A *Lolium* species identified during 2006 as a potentially invasive plant was omitted from the 2010 list. We believe the species is best identified as wheat grass (*Pascopyrum smithii),* a native cool-season grass. Consequently, this species is not included in this report.

Analytical methods

Data analysis involved simple displays, as well as calculation of plant cover and frequency. The invasive exotic plants encountered in Tallgrass Prairie National Preserve were attributed to line transects in a GIS (Figures 2-20). Squares surrounding occupied line transects were highlighted on maps for each invasive plant species encountered. Note that entire squares were not fully searched. A park-wide cover range was estimated for each invasive plant species encountered.

Calculations of the observed reference frame fraction were made by multiplying transect length, the number of transects, and the belt width. The belt width was either 3 m (the minimum possible width) or 12 m (the maximum possible width). Transect length was calculated by summing the lengths of the 301 transects. The product was then divided by the reference frame area (Eq. 1).

$$\text{Eq.1. Fraction of area searched} = \frac{\textit{transect length} * \textit{number of transects} * \textit{belt width}}{\textit{reference frame area}}$$

The minimum fraction of area searched (belt width = 3 m) was 0.0075, and the maximum fraction of area searched (belt width = 12 m) was 0.0298.

To calculate the minimum end of the estimated cover range for each species, the lower endpoints associated with the assigned cover class values for that species were summed and then divided by the reference frame fraction observed assuming the widest possible survey belt (i.e., maximum fraction observed) (Eq. 2).

Eq.2. Minimum cover estimate = $\frac{\Sigma \text{ low end of cover value range for species}}{\text{fraction of area searched assuming 12-m belt width}}$

Maximum cover for each species was calculated similarly, using the upper endpoints of the cover values in each occupied search unit and assuming that a 3 m belt was surveyed (i.e., minimum fraction of area observed) (Eq. 3).

Eq. 3. Maximum cover estimate = $\frac{\Sigma \text{ high end of cover value range for species}}{\text{fraction of area searched assuming 3-m belt width}}$

Taken together, the minimum and maximum cover estimates provide an estimated range of cover that accounts for the uncertainty arising from the sampling method. Non-overlapping ranges represent the strongest evidence for differences in abundance.

The park-wide frequency of invasive exotic plants was calculated as the percentage of occupied search units (Eq. 4).

Eq. 4. Frequency of an invasive plant species = $\frac{\Sigma \text{ units occupied by species}}{\Sigma \text{ units sampled}}$ X100

Abundance range estimates of invasive plant species in the 2006 report (Young et al. 2007b) were recalculated to follow the latest protocol version (Young et al. 2007a). In the 2006 report, the abundance estimates assumed that an entire 12-m belt was searched, whereas in 2010 we recalculated the 2006 data to reflect variation of between 3m and 12m in belt width. Consequently, the cover ranges presented in the 2006 report were narrower than those shown in this report.

Invasiveness ranks

In order to provide additional information on the ecological impact and feasibility of control, the ecological impact and general management difficulty sub-ranks that constitute the invasiveness rank (I-rank), as determined by NatureServe (Morse et al. 2004), were listed when available. The ecological impact characterizes the effect of the plant on ecosystem processes, community composition and structure, native plant and animal populations, and the conservation significance of threatened biodiversity. General management difficulty ranks are assigned based on the resources and time generally required to control a plant, the non-target effects of control on native populations, and the accessibility of invaded sites. Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), or a combination of ranks.

Results and Discussion

In 2006 and 2010, a cumulative total of 19 invasive exotic plant taxa were documented in Tallgrass Prairie National Preserve. In 2006 and 2010, 15 and 18 species were recorded, respectively. Caucasian bluestem (*Bothriochloa bladhii*), tree-of-heaven (*Ailanthus altissima*), Kentucky bluegrass (*Poa pratensis*), and tall fescue (*Schedonorus phoenix*) were only recorded during the 2010 survey. Although Caucasian bluestem was known to be present on pond dams,

and Kentucky bluegrass was known to occur throughout the prairie during 2006, the species were not recorded. Likewise, tall fescue was known from the smooth brome-dominated fields adjacent to Fox Creek, but was not recorded. Tree-of-heaven, included on the early detection watch list, was a newly documented invasive plant occurrence. Spotted knapweed (*Centaurea stoebe ssp. micranthos*) was the only species found in 2006, but not 2010.

The abundance of invasive exotic plant species found during the surveys in Tallgrass Prairie National Preserve varied widely. Smooth brome (*Bromus inermis*) was the most abundant invasive plant, covering at least 32 acres in 2006 and 83 acres in 2010. Maximum cover of only seven of nineteen invasive exotic plants exceeded 10 acres. This included all five grasses identified in the survey: the cool-season grasses Japanese brome (*Bromus japonicus*), Kentucky bluegrass, smooth brome, and tall fescue and the warm-season Johnsongrass. Two forbs, spreading hedgeparsley (*Torilis arvensis*) and buffalobur nighshade (*Solanum rostratum*), also potentially covered over 10 acres. Overall, based on the sum of the minimum cover estimates for all species encountered in each survey, total invasive plant cover in the park increased from an estimated 45.8 acres in 2006 acres to 126.3 acres in 2010. This difference resulted entirely, however, from differences in the estimate of smooth brome cover, which because of its abundance is subject to substantial estimation error (Young and Haack 2009).

Potential Sources of Error in Plant Detection

Comparisons of invasive plant frequency between 2006 and 2010 required careful consideration of the uncertainty associated with the measurements outlined in the monitoring protocol. First, observers can make mistakes in their observations such as overlooking or misidentifying plants within transects. The use of trained botanists and technicians is intended to minimize this source of uncertainty. Second, because transect locations and widths may vary between years, differences in plant detection may reflect natural spatial variability. This factor may strongly affect plant detection rates in any single search unit, but should vary randomly across all units. Such sampling error, which should be mitigated through the approximately similar location of transects between years, poses the greatest challenge to data interpretation in this protocol. While we observed a high portion of the reference frame compared to traditional sampling approaches (Young and Haack 2009), observers cannot observe all areas of the park. Additional observations from park staff or citizen scientists would increase detection of invasive plant species.

Given these sources of error, three possible scenarios could characterize changes in the frequency of invasive plant species between 2006 and 2010. In the first scenario, a species found on a transect during the first and second surveying periods confirmed the longevity of the species in that location. In the second scenario, in which a species was not found along a transect during either surveying period, we assumed that the species was absent or at least not highly abundant or widely distributed as these characteristics would increase detection probabilities. The third scenario–when a species found along a transect during one survey and not during another–was the most problematic. This observation could reflect species turnover or a dramatic fluctuation in abundance that is typically associated with annual species. Alternatively, a species may have been present, but not recorded either due to observer mistakes or to sampling error arising from the use of non-permanent transects and variable belt widths along transects. For this study, the relatively high abundances recorded for several species during only the second survey led us to assume that observer errors accounted for these differences and that these species were likely

present during both survey periods. Thus, if it is desirable to control select species, we advise managers to visit all areas where the species occurred in either 2006 or 2010.

The assumption made here for the third scenario will not always be appropriate. For example, a species that is not found or found at low frequency during an early surveying period and is then found in a relatively large number of transects during a later surveying period may be actively invading. Alternatively, for species subject to control actions, decreases in frequency between or among surveys could result from such management. Relatively dramatic changes in frequency, however, will only be expected for species with low abundance that respond readily to management techniques. In either case, such patterns will be best documented by increasing or decreasing trends from several years of survey data, and it is difficult in most cases to make definitive conclusions from only two years of data.

Changes in Invasive Plant Frequencies

Of the 14 invasive plant species found during both surveys, 71.4% and 57.1% occurred in less than 5% of transects in 2006 and 2010, respectively. Only buffalobur nightshade and Japanese brome exhibited high frequencies (>20%); these species, included on the park-based watchlist, are not considered highly invasive. Overall, the frequency increased for 57.1%, decreased for 28.6%, and did not change for 14.3% of species between 2006 and 2010. All increases were generally slight with the exception of sweetclover (*Melilotus officinalis*), Japanese brome, and spreading hedgeparsley. The increase in sweetclover may reflect spread or natural variability in populations of this weedy biennial. Observation errors resulting from the later survey date in 2006 may have contributed to the large frequency increases of Japanese brome and spreading hedgeparsley, which as spring-blooming species become increasingly difficult to identify in the late summer.

Potential Sources of Error in Plant Abundance Estimation

Interpreting changes in the abundance of invasive plant species between 2006 and 2010 required considerations of uncertainty in addition to those made for frequency. For example, in addition to observer detection mistakes, abundance estimates include error resulting from incorrect assignment of cover classes. As with detection, abundance estimation may vary between years due to variability in transect location, although the approximate similarity in location between years should mitigate this error. The uncertainty resulting from measurement error (i.e., the use of cover class ranges rather than point estimates) and the uncertainty resulting from variable belt widths are accounted for in the cover range provided for each invasive plant species (see *Analytical Methods*). For the purposes of comparing cover ranges for each species between 2006 and 2010, non-overlapping cover ranges represent the strongest evidence for a change in the abundance of a species. Cover ranges may be very broad, however, and increase with abundance. Thus, relatively large differences in overlapping cover ranges could also be informative. For such overlapping cover ranges, the degree of overlap should be proportional to the strength of evidence for a true difference in abundance. Consequently, a high degree of overlap in range represents a lower probability of a difference than a low degree of overlap.

Changes in Invasive Plant Abundances

Based on non-overlapping cover ranges, we identified only sweetclover as increasing from an estimate of 0.01-0.4 acres in 2006 to 0.6-8.0 acres in 2010. This increase matched an increase in frequency. The five-fold or greater increase in the cover estimates also suggested increases in

bull thistle (*Cirsium vulgare*), Eastern red cedar (*Juniperus virginiana*), and spreading hedgeparsley (*Torilis arvensis*) in Tallgrass Prairie National Preserve, although as mentioned above, observer error associated with timing of the survey may account for the differences in spreading hedgeparsley. The abundance of lesser burdock (*Arctium minus*) and Callery pear (*Pyrus calleryana*) did not change between years. We interpreted the rest of the overlapping ranges as reflecting general similarity in abundance between 2006 and 2010. Viewing the entire suite of invasive species with abundance greater than 0 during 2006 and 2010 as a whole (n=14), the maximum cover estimate increased for 71.4% of species, decreased for 14.4 % of species, and did not change for 14.4% of species.

Implications for Invasive Plant Management

Two species were noted as having high to medium ecological impact: black locust and narrowleaf/hybrid cattail (Table 2). A medium ecological impact characterized five of the surveyed species. The remaining species have ambiguous medium-low ecological impacts or less with a low or insignificant impact. Recognizing that the feasibility of control often strongly influences decisions regarding invasive exotic plant management, Johnsongrass and spotted knapweed were the only species noted as potentially difficult to control. In general, the tallgrass prairie appears to resist invasions of most plants, although park staff must spot-treat Chinese lespedeza (Lespedeza cuneata) and black swallowwort (Cyanchum louiseae). The restored prairies, smooth brome-dominated pasture, riparian forests, and road sides currently support the majority of invasive plants. Current efforts to prevent or reduce existing invasions will necessarily focus on these areas.

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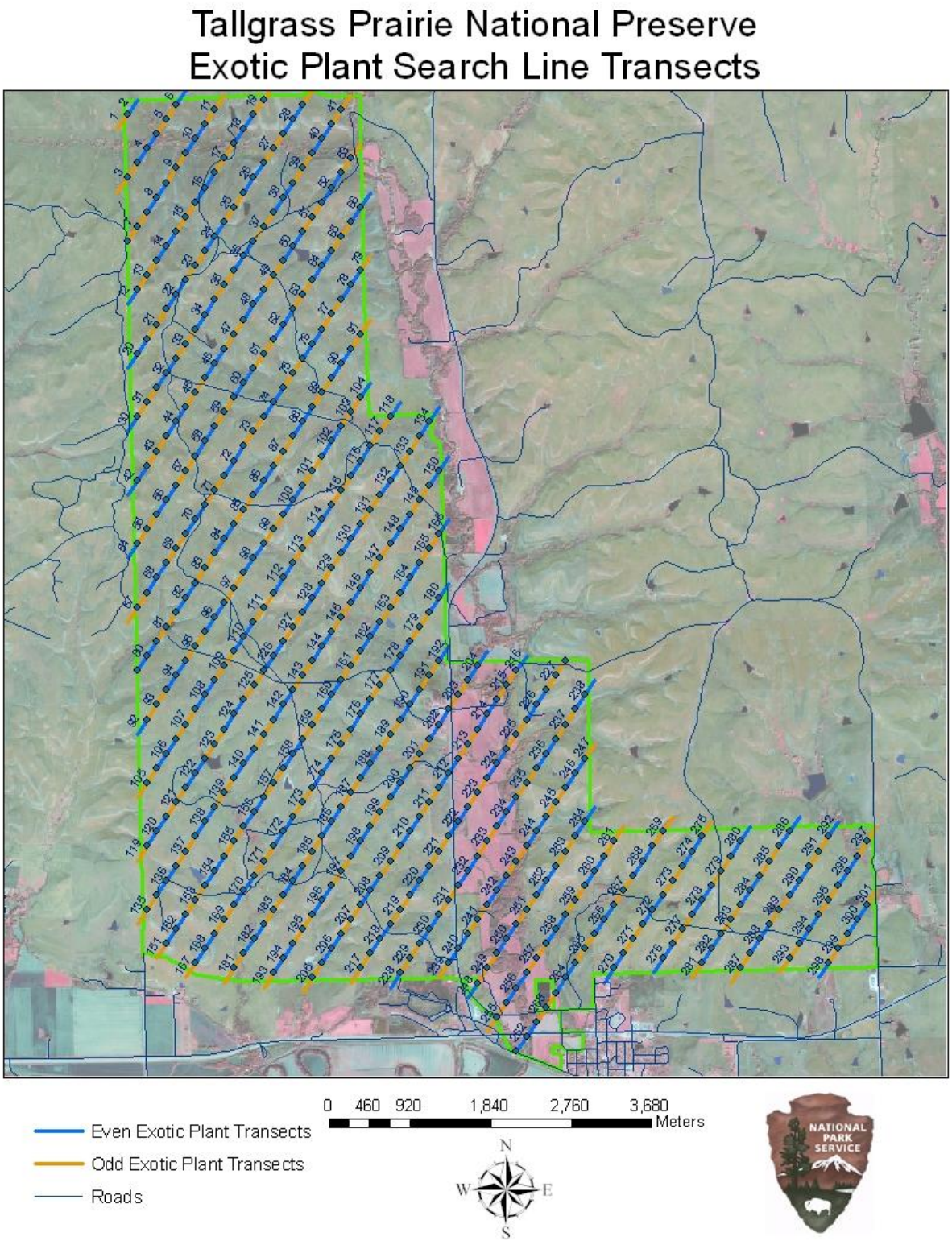

Figure 1. Invasive exotic plant line transects at Tallgrass Prairie National Preserve. The blue (even numbered) and orange (odd numbered) transects indicate the search locations for invasive exotic plants in 2006 and 2010.

Table 1. Watch lists for Tallgrass Prairie National Preserve

Early Detection Watch List		Park-Established Watch List		Park-Based Watch List	
Ailanthus altissima	Tree of heaven	*Alliaria petiolata*	Garlic mustard	*Bassia scoparia*	Burningbush
Alnus glutinosa	European alder	*Arctium minus*	Lesser burdock	*Bromus racemosus*	Bald brome
Arundo donax	Giant reed	*Bromus inermis*	Smooth brome	*Cirsium arvense*	Canada thistle
Azolla	Mosquitofern	*Bromus tectorum*	Cheatgrass	*Juniperus virginiana*	Eastern red cedar
Berberis thunbergii	Japanese barberry	*Carduus nutans*	Nodding plumeless thistle	*Solanum rostratum*	Buffalobur nightshade
Bothriochloa bladhii	Caucasian bluestem	*Holcus lanatus*	Common velvetgrass	*Bromus japonicus*	Japanese brome
Centaurea solstitialis	Yellow star-thistle	*Melilotus officinalis*	Yellow sweetclover		
Centaurea stoebe ssp. micranthos	Spotted knapweed	*Morus alba*	White mulberry		
Cirsium vulgare	Bull thistle	*Poa pratensis*	Kentucky bluegrass		
Cynanchum louiseae	Louise's swallow-wort	*Robinia pseudoacacia*	Black locust		
Dactylis glomerata	Orchardgrass	*Rosa multiflora*	Multiflora rose		
Dioscorea oppositifolia	Chinese yam	*Schedonorus pheonix*	Tall fescue		
Dipsacus fullonum	Fuller's teasel	*Sorghum halepense*	Johnsongrass		
Dipsacus laciniatus	Cutleaf teasel	*Ulmus pumila*	Siberian elm		
Egeria densa	Brazilian waterweed	*Verbascum thapsus*	Common mullein		
Elaeagnus angustifolia	Russian olive				
Elaeagnus umbellata	Autumn olive				
Euonymus fortunei	Winter creeper				
Euphorbia esula	Leafy spurge				
Glechoma hederacea	Ground ivy				
Hesperis matronalis	Dames rocket				
Humulus japonicus	Japanese hop				
Lespedeza bicolor	Shrub lespedeza				
Lespedeza cuneata	Sericea lespedeza				
Lonicera japonica	Japanese honeysuckle				
Lonicera maackii	Amur honeysuckle				
Lonicera tatarica	Tatarian honeysuckle				
Lotus corniculatus	Bird's-foot trefoil				
Lotus glaber	Narrow-leaf bird's-foot trefoil				
Lysimachia nummularia	Creeping jenny				

Table 1. Watch lists for **Tallgrass Prairie National Preserve** (cont.)

Early Detection Watch List		Park-Established Watch List		Park-Based Watch List	
Lythrum salicaria	Purple loosestrife				
Myriophyllum aquaticum	Parrot feather watermilfoil				
Pastinaca sativa	Wild parsnip				
Phalaris arundinacea	Reed canarygrass				
Phragmites australis	Common reed				
Plantago lanceolata	Narrowleaf plantain				
Poa compressa	Canada bluegrass				
Polygonum cuspidatum	Japanese knotweed				
Populus alba	White poplar				
Potamogeton crispus	Curly pondweed				
Potentilla recta	Sulphur cinquefoil				
Pueraria montana var. lobata	Kudzu				
Pyrus calleryana	Callery pear				
Rhamnus cathartica	Common buckthorn				
Schedonorus pratensis	Meadow fescue				
Securigera varia	Crownvetch				
Solanum dulcamara	Climbing nightshade				
Tamarix ramosissima	Saltcedar				
Torilis arvensis	Spreading hedgeparsley				
Torilis japonica	Erect hedgeparsley				
Typha angustifolia	Narrowleaf cattail				
Vinca minor	Common periwinkle				

Table 2. Overview of invasive exotic plants found on Tallgrass Prairie National Preserve. Ecological impact and general management difficulty based on NatureServe I-Rank subranks, Morse et al. 2004. Subranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), a range of ranks (indicated by /), or not available (--).

Scientific Name	Common Name	Watch list	2006 Park-wide cover (acres)	2010 Park-wide cover (acres)	2006 Frequency (%)	2010 Frequency (%) (Frequency difference 2006-2010)	Ecological impact	Management difficulty
Ailanthus altissima	Tree of heaven	Early detection	0	0.01 - 0 3	0	0.3 (0.3)	ML	ML
Alliaria petiolota	Garlic mustard	Park-established	0.1 – 2.9	0.3 – 6.3	1.7	2.7 (1.0)	ML	M
Arctium minus	Lesser burdock	Park-established	0.002 - 0.1	0.002 - 0.1	1.0	0.7 (-0.3)	LI	MI
Bothriochloa bladhii	Caucasian bluestem	Early detection	0	0.01 – 0.3	0	0.3 (0.3)	----	----
Bromus inermis	Smooth brome	Park-established	32.3 – 902.0	83.3 – 1546.8	7.0	9.0 (2.0)	M	ML
Bromus japonicus	Japanese/Bald brome	Park-based	11.7 – 224.9	32.9 – 524.9	14.0	35.5 (21.5)	----	----
Centaurea stoebe ssp. micranthos	Spotted knapweed	Early detection	0.01 - 0 3	0	0.3	0 (-0.3)	M	HL
Cirsium vulgare	Bull thistle	Early detection	0.02 – 0.7	0.4 – 4.1	1.0	2.3 (1.3)	ML	ML
Juniperus virginiana	Eastern redcedar	Park-based	0.03 – 1.1	0.3 – 5.6	2.3	1.7 (-0.6)	----	----
Melilotus officinalis	Sweetclover	Park-established	0.01 – 0.4	0.6 – 8.0	0.7	5.6 (4.9)	M	M
Morus alba	White mulberry	Park-established	0.1 – 2.0	0.4 – 4.1	1.0	2.3 (1.3)	ML	ML
Poa pratensis	Kentucky bluegrass	Park-established	0	0.7 – 16.1	0	7.3 (7.3)	M	ML
Pyrus calleryana	Callery pear	Early detection	0.1 – 1.6	0.1 – 1.6	0.3	0.3 (0)	LI	ML
Robinia pseudoacacia	Black locust	Park-established	0.1 – 1.6	0.01 - 0 3	0.3	0.3 (0)	HM	M
Schedonorus phoenix	Tall fescue	Park-established	0	2.6 – 47.1	0	4.7 (4.7)	----	----
Solanum rostratum	Buffalobur nightshade	Add to park-based	0.3 – 11.6	0.4 – 10.7	22.6	22.9 (0.3)	----	----
Sorghum halepense	Johnson grass	Park-established	1.0 – 14.8	1.3 – 21.1	4.0	2.3 (-1.7)	ML	HM
Torilis arvensis	Spreading hedgeparsley	Early detection	0.1 – 2.0	1.3 – 17.9	2.3	7.0 (5.7)	----	----
Typha angustifolia/X glauca	Narrowleaf cattail/Hybrid cattail	Early detection	0.02 – 1.0	0.2 – 3.3	1.0	0.7(-0.3)	HM	M

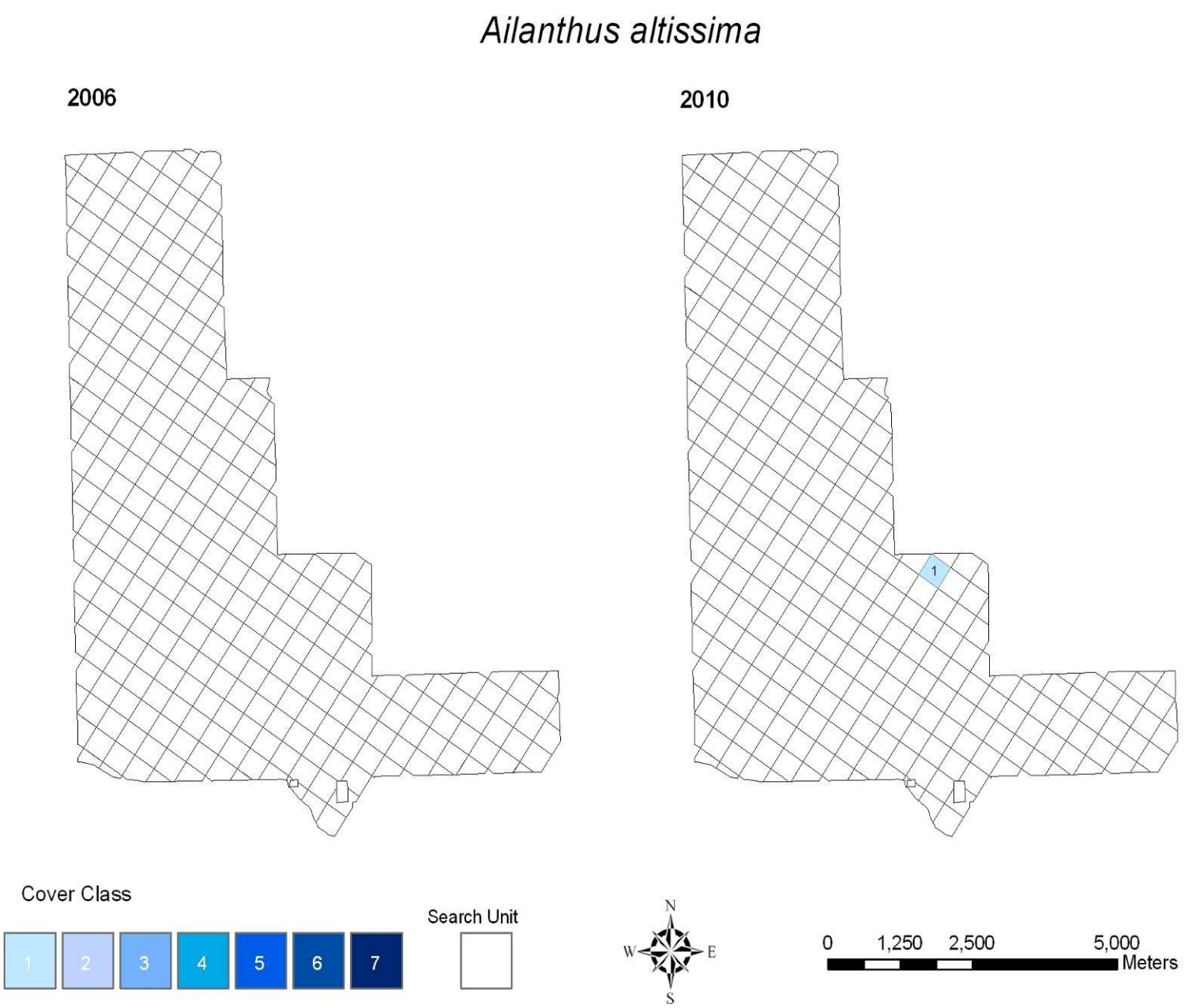

Figure 2. Abundance and distribution of *Alianthus altissima* (tree of heaven) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

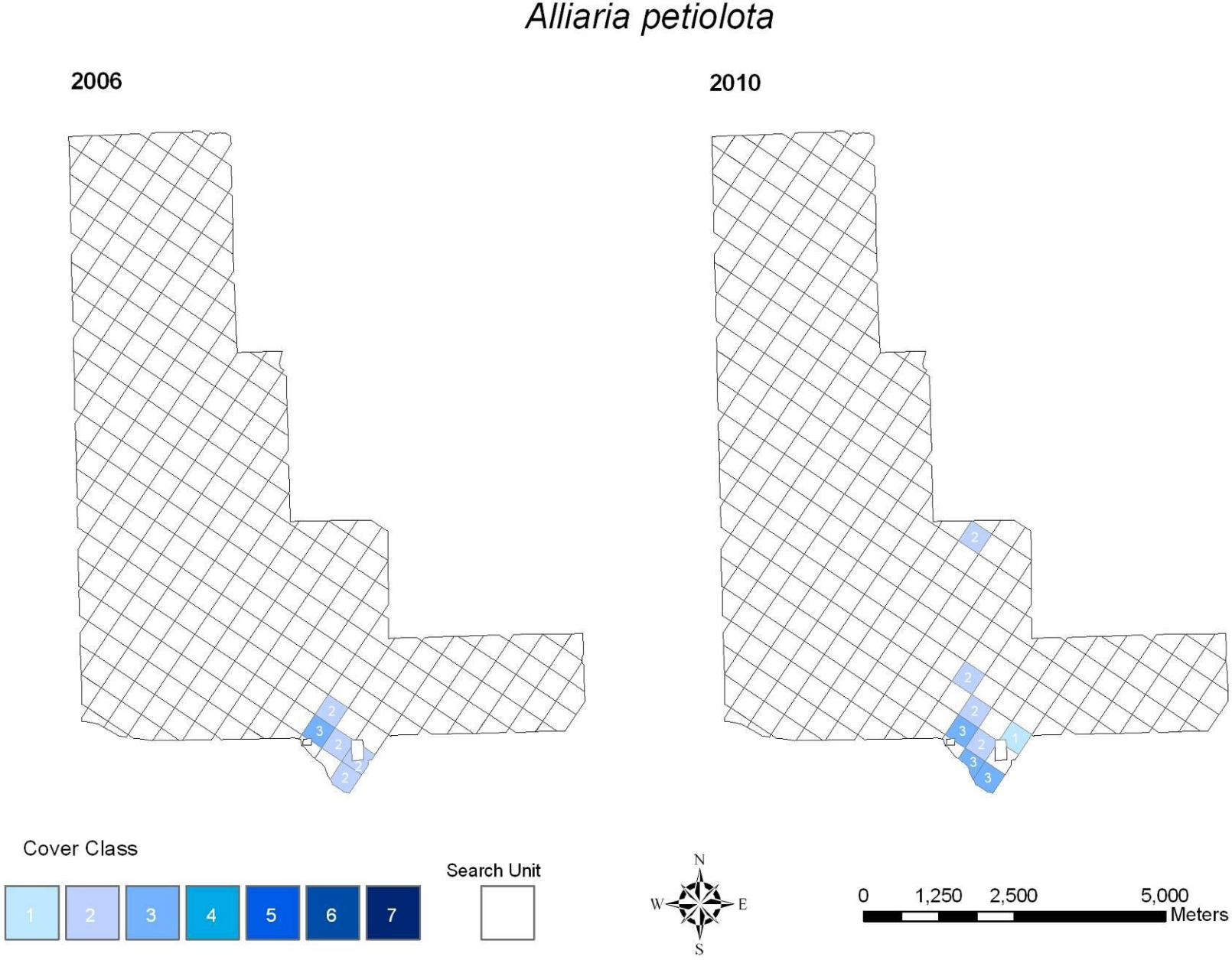

Figure 3. Abundance and distribution of *Alliaria petiolata* (garlic-mustard) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

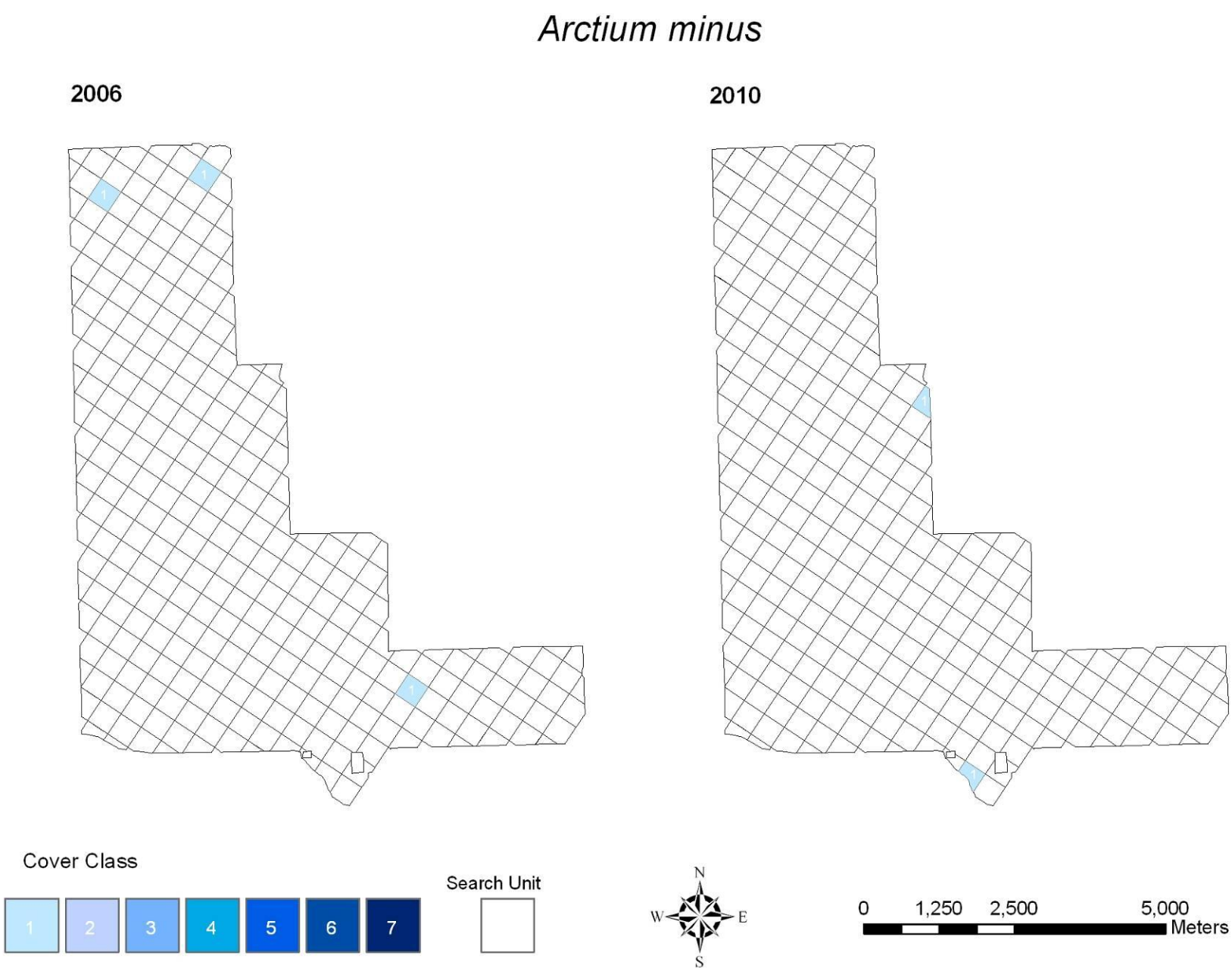

Figure 4. Abundance and distribution of *Arctium minus* (lesser burdock) at Tallgrass Prairie National Preserve**,** 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

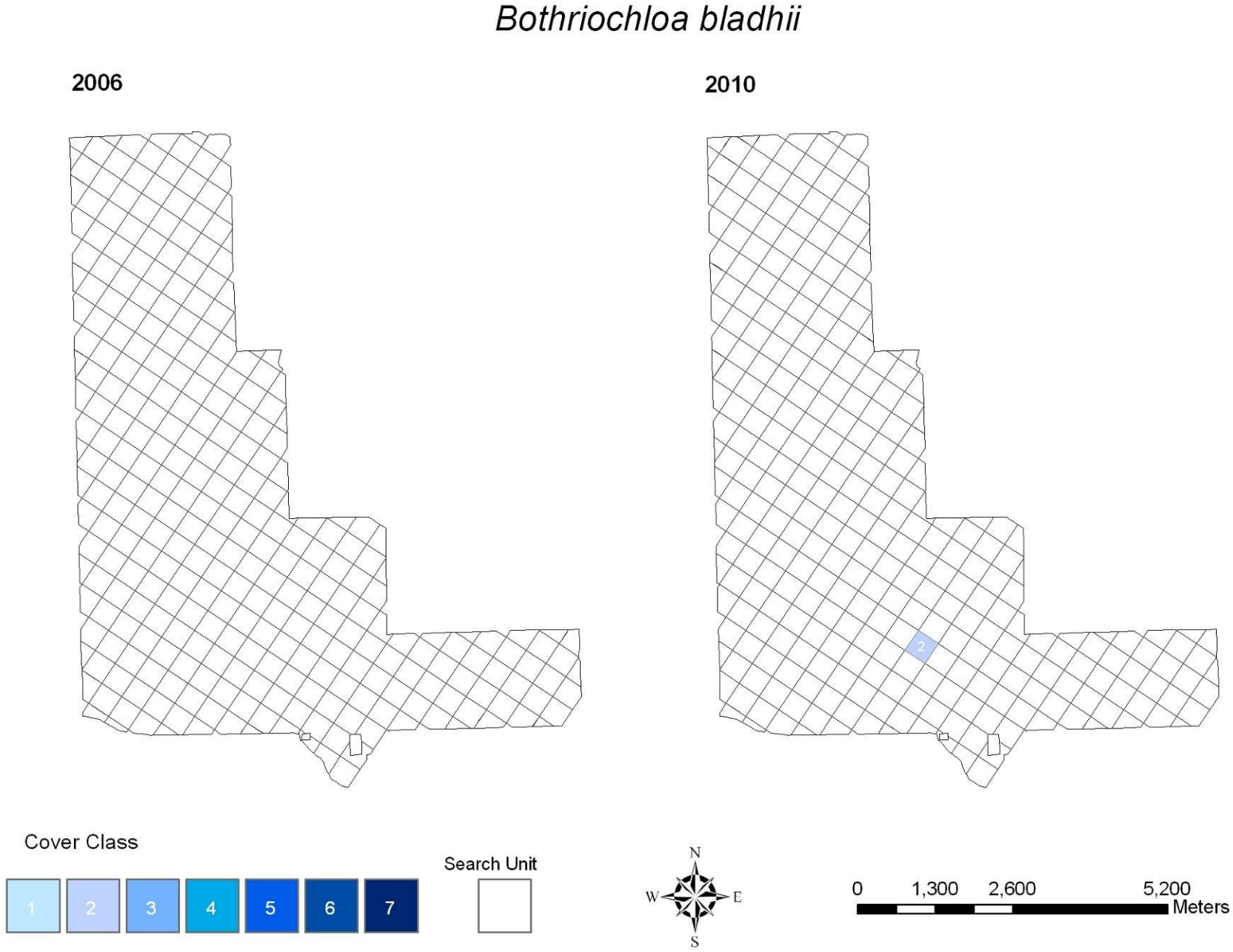

Figure 5. Abundance and distribution of *Bothriochloa bladhii* (Caucasian bluestem) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

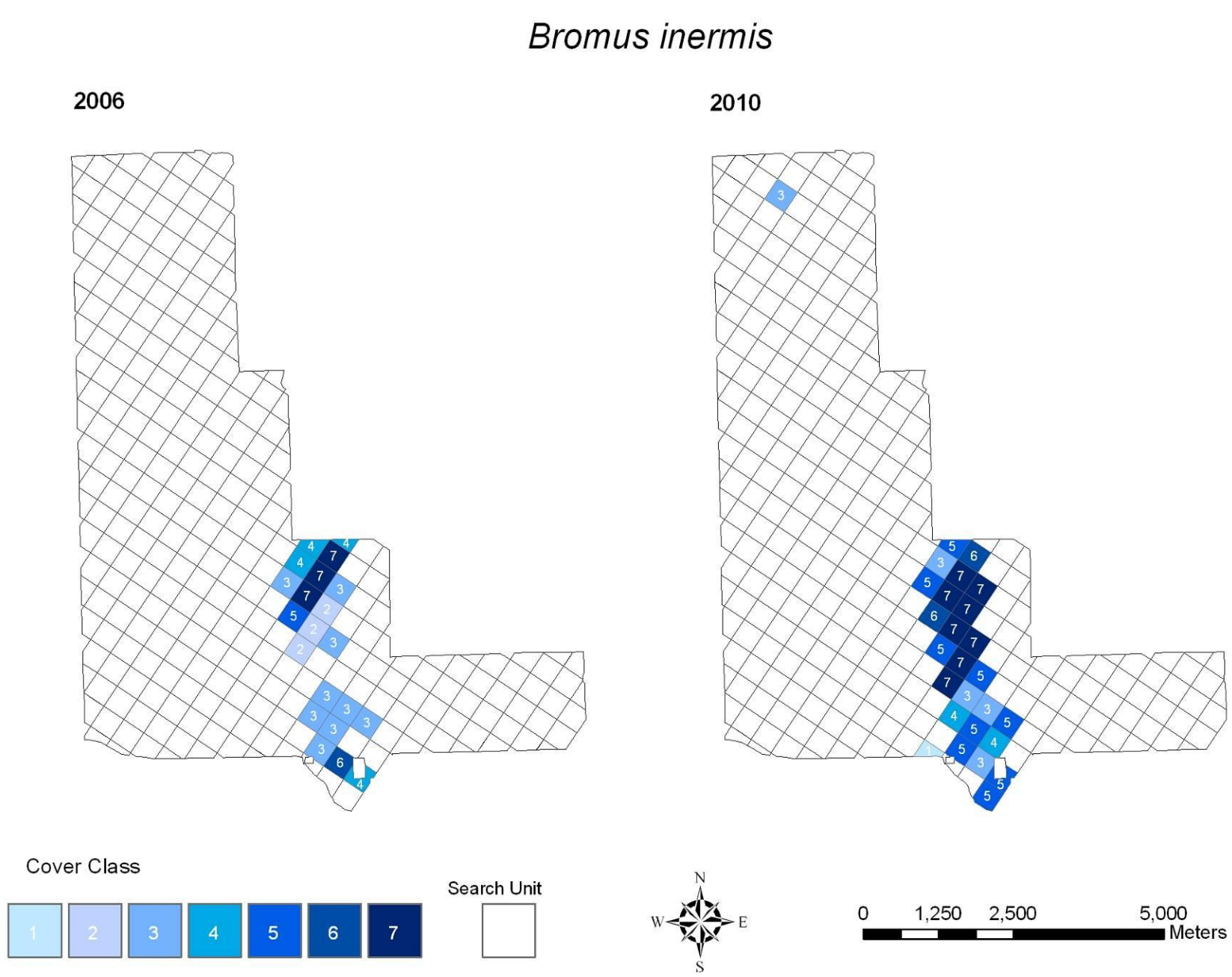

Figure 6. Abundance and distribution of *Bromus inermis* (smooth brome) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

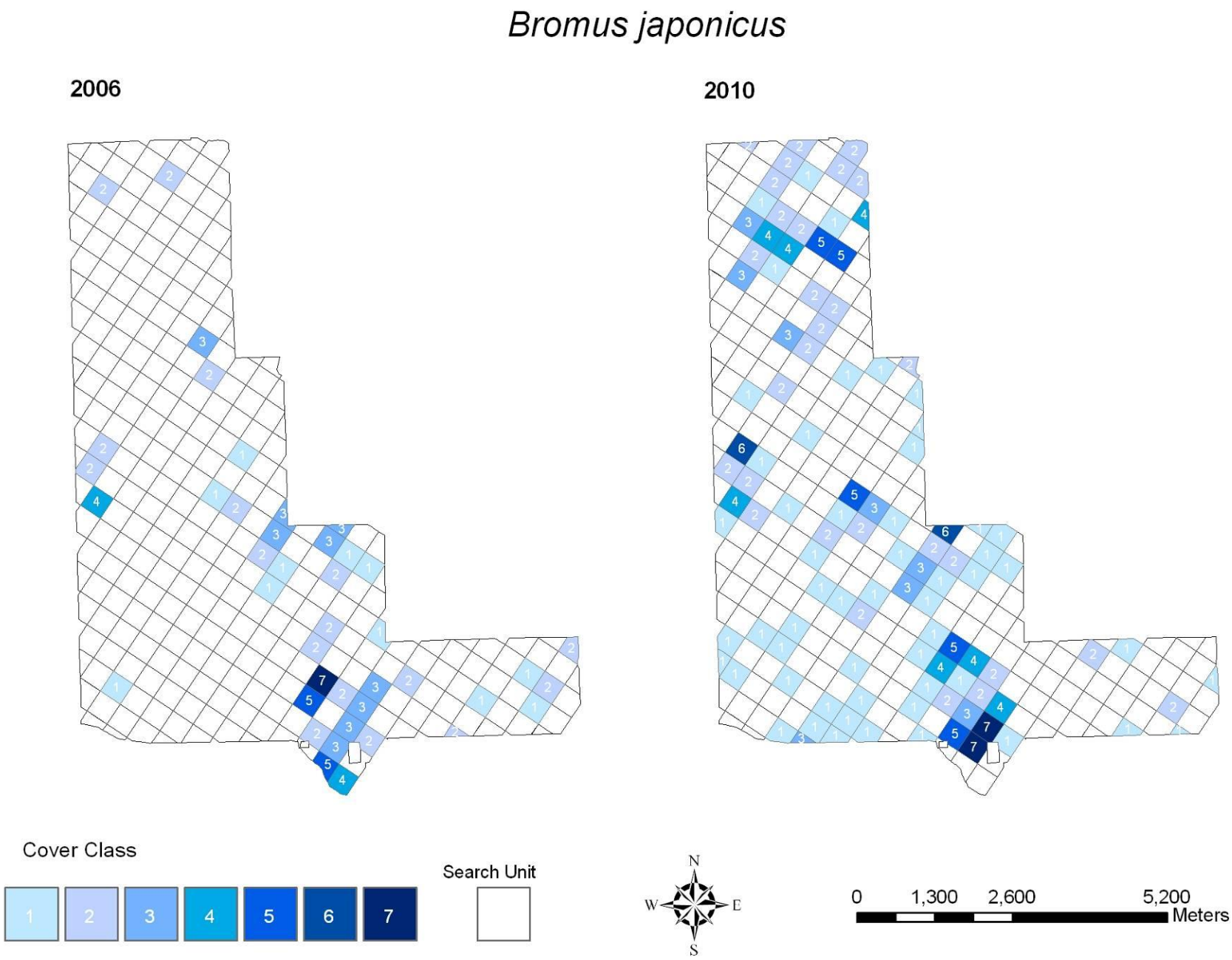

Figure 7. Abundance and distribution of *Bromus japonicus* (Japanese brome) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

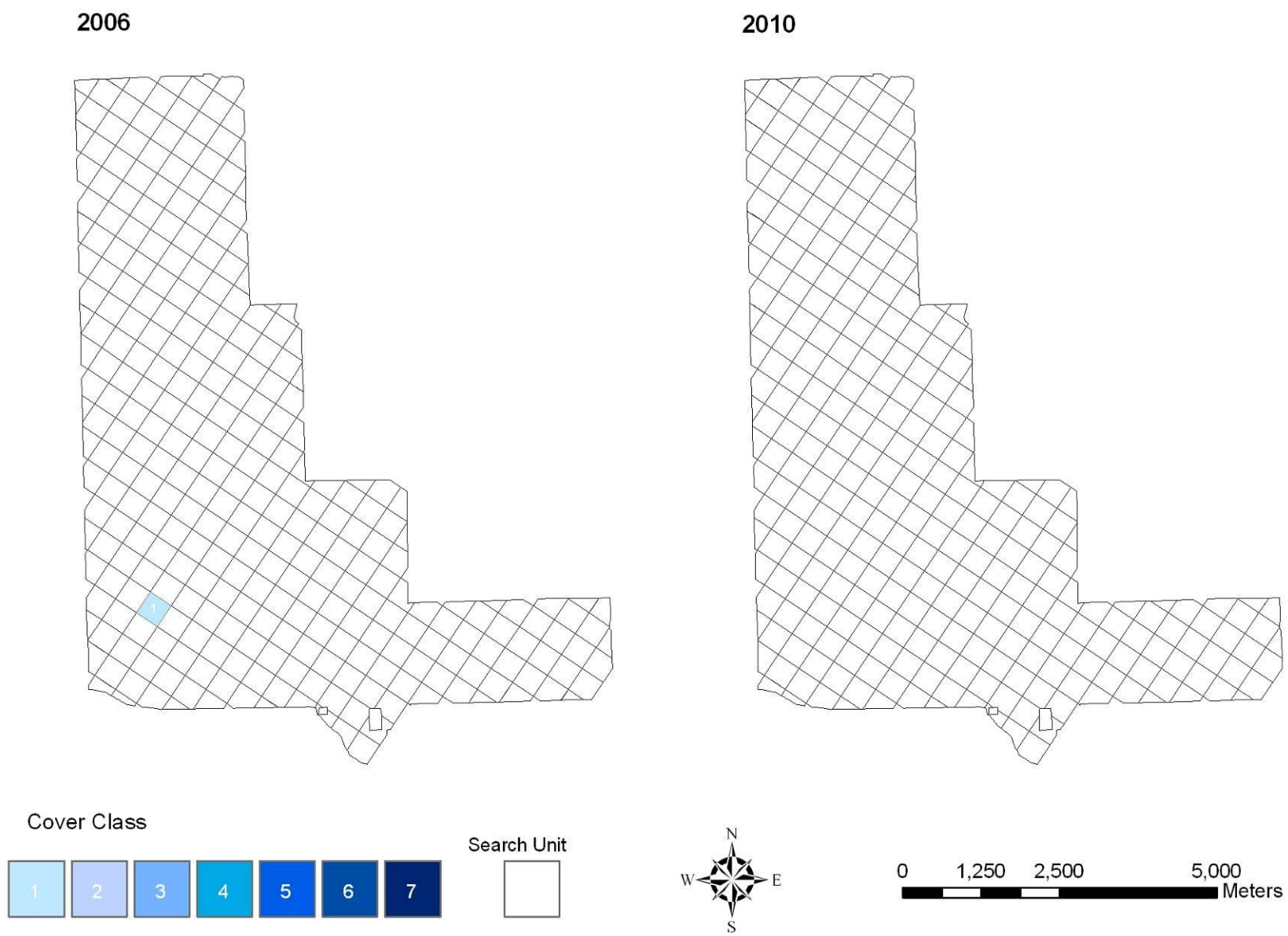

Figure 8. Abundance and distribution of *Centaurea stoebe ssp. micranthos* (spotted knapweed) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

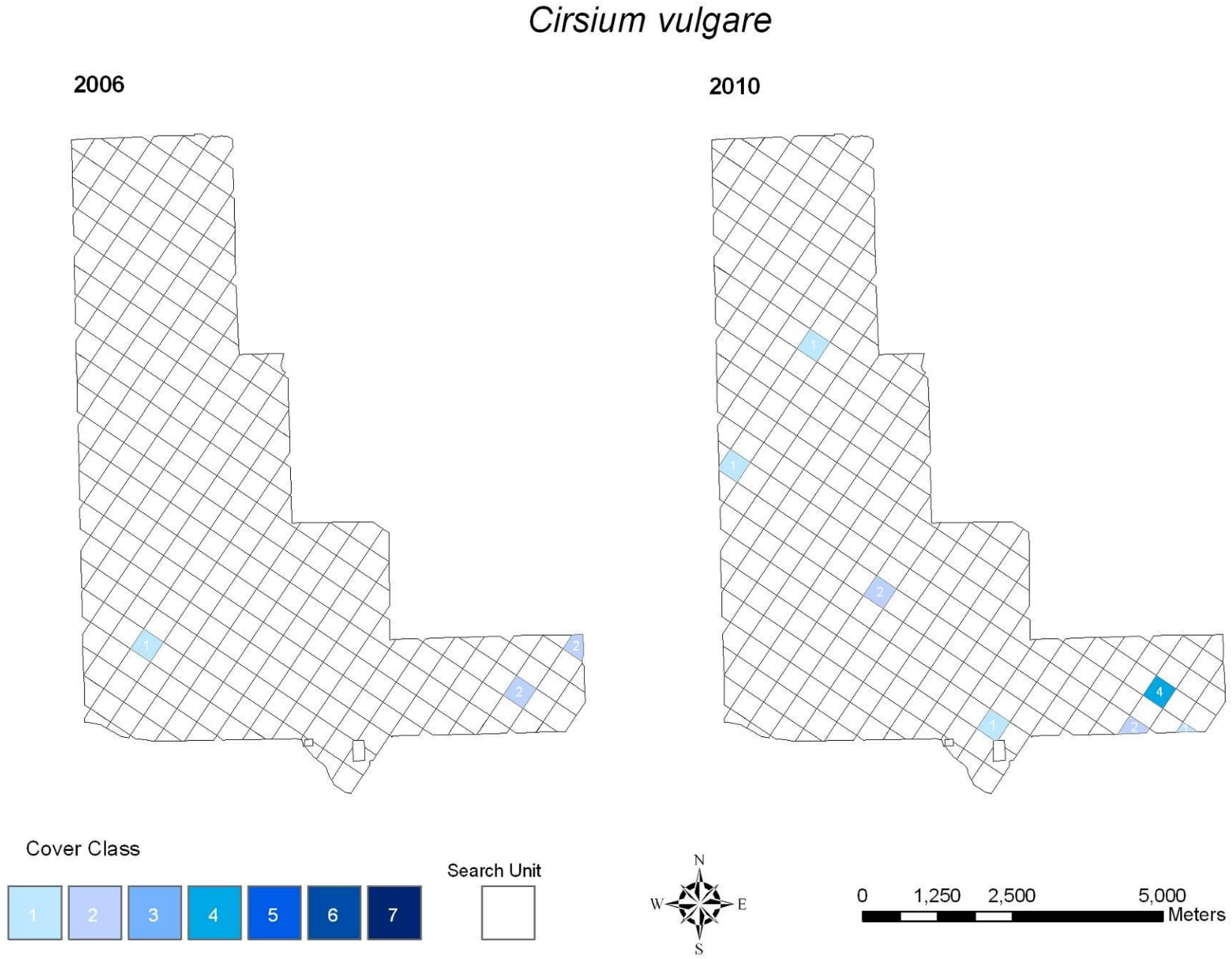

Figure 9. Abundance and distribution of *Cirsium vulgare* (bull thistle) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

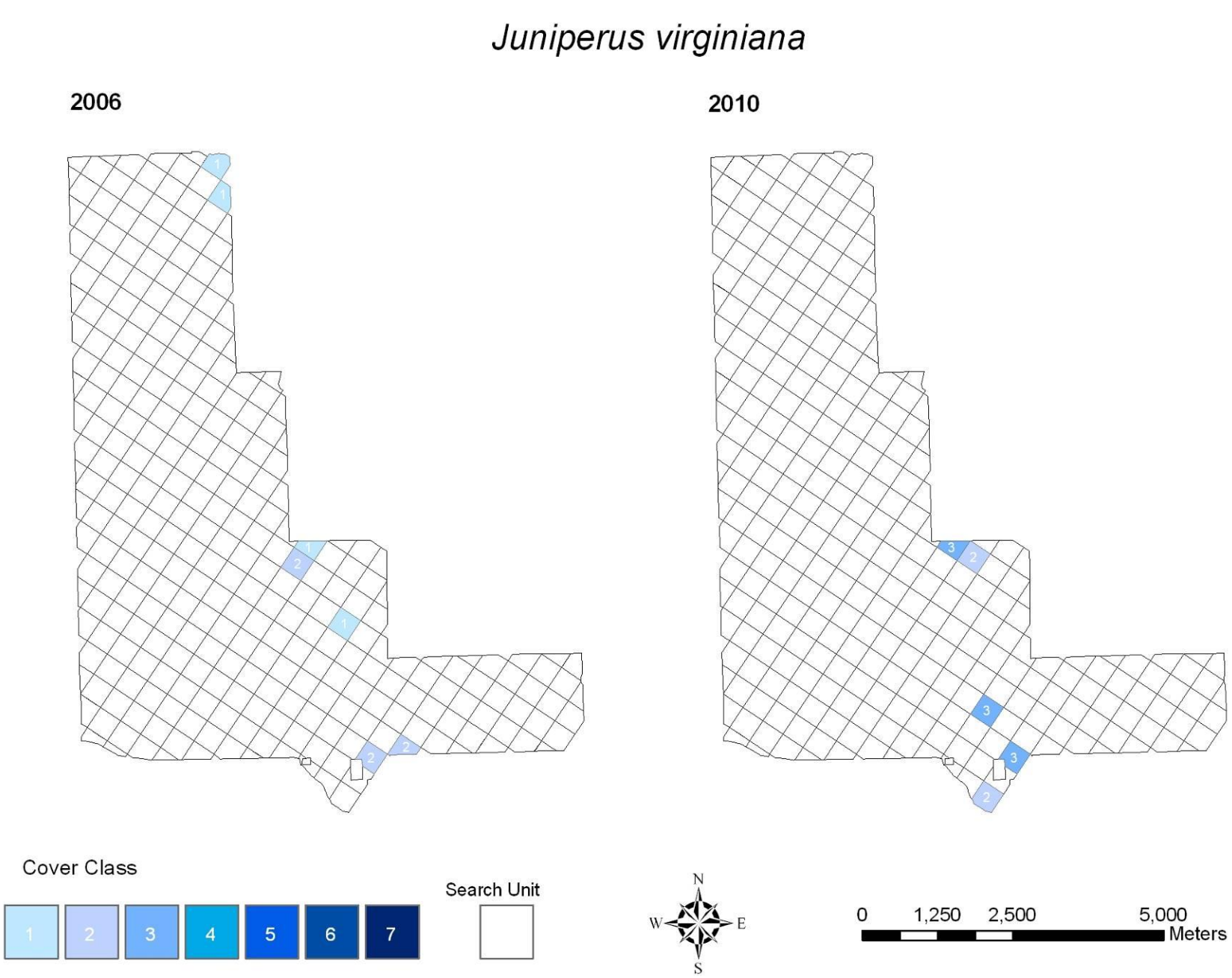

Figure 10. Abundance and distribution of *Juniperus virginiana* (Eastern red cedar) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

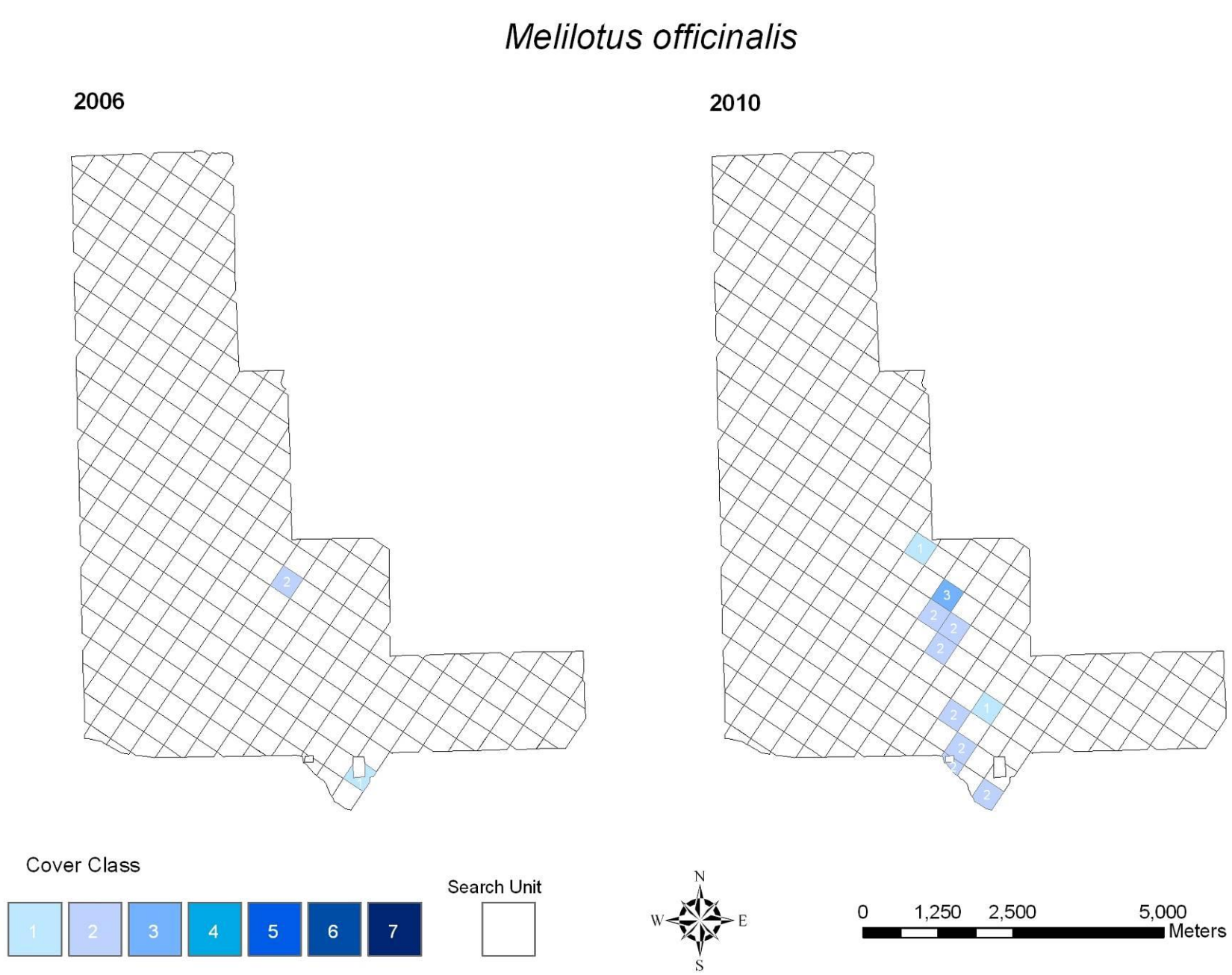

Figure 11. Abundance and distribution of *Melilotus officinalis* (sweet clover) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

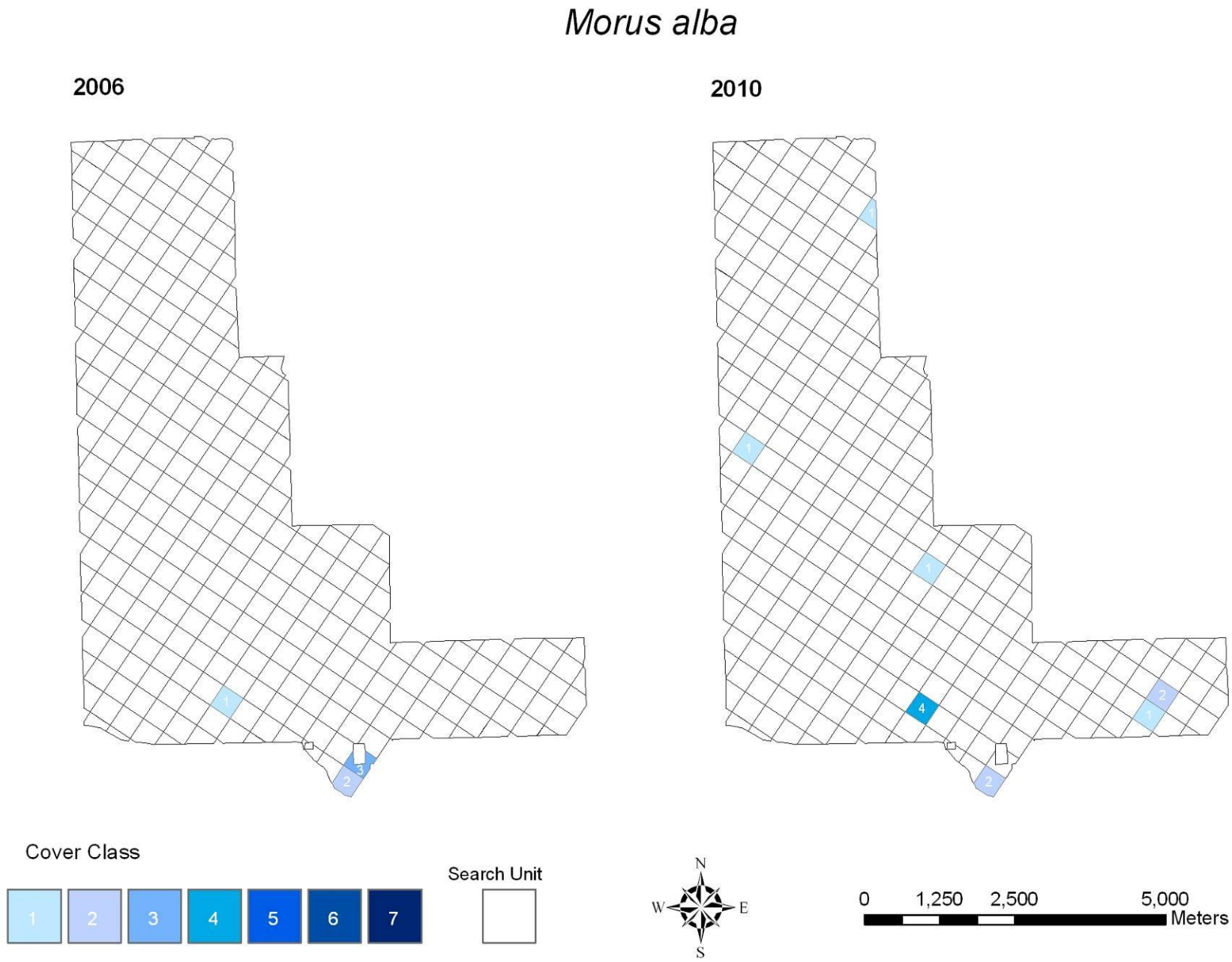

Figure 12. Abundance and distribution of *Morus alba* (white mulberry) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

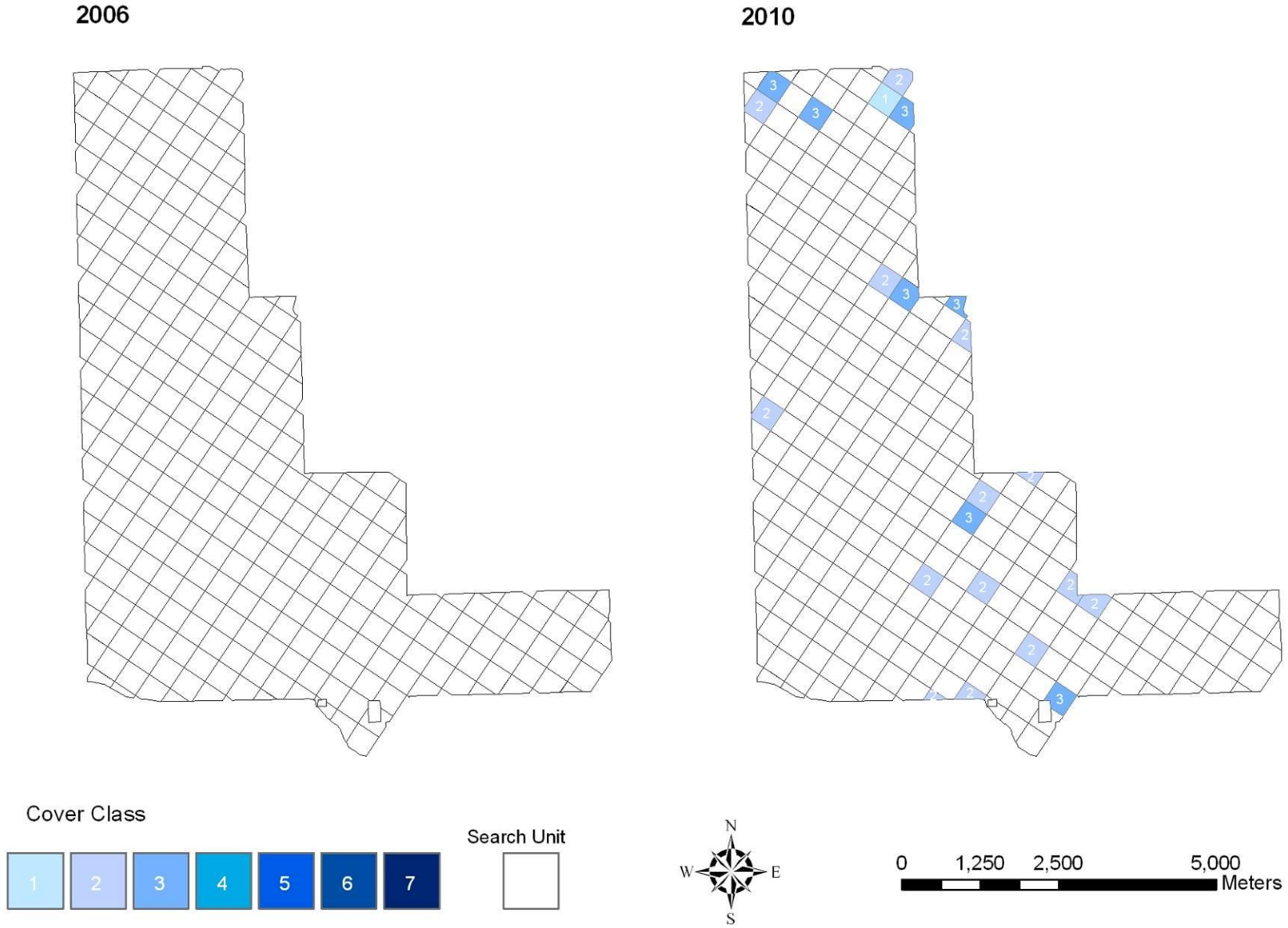

Figure 13. Abundance and distribution of *Poa pratensis* (Kentucky bluegrass) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

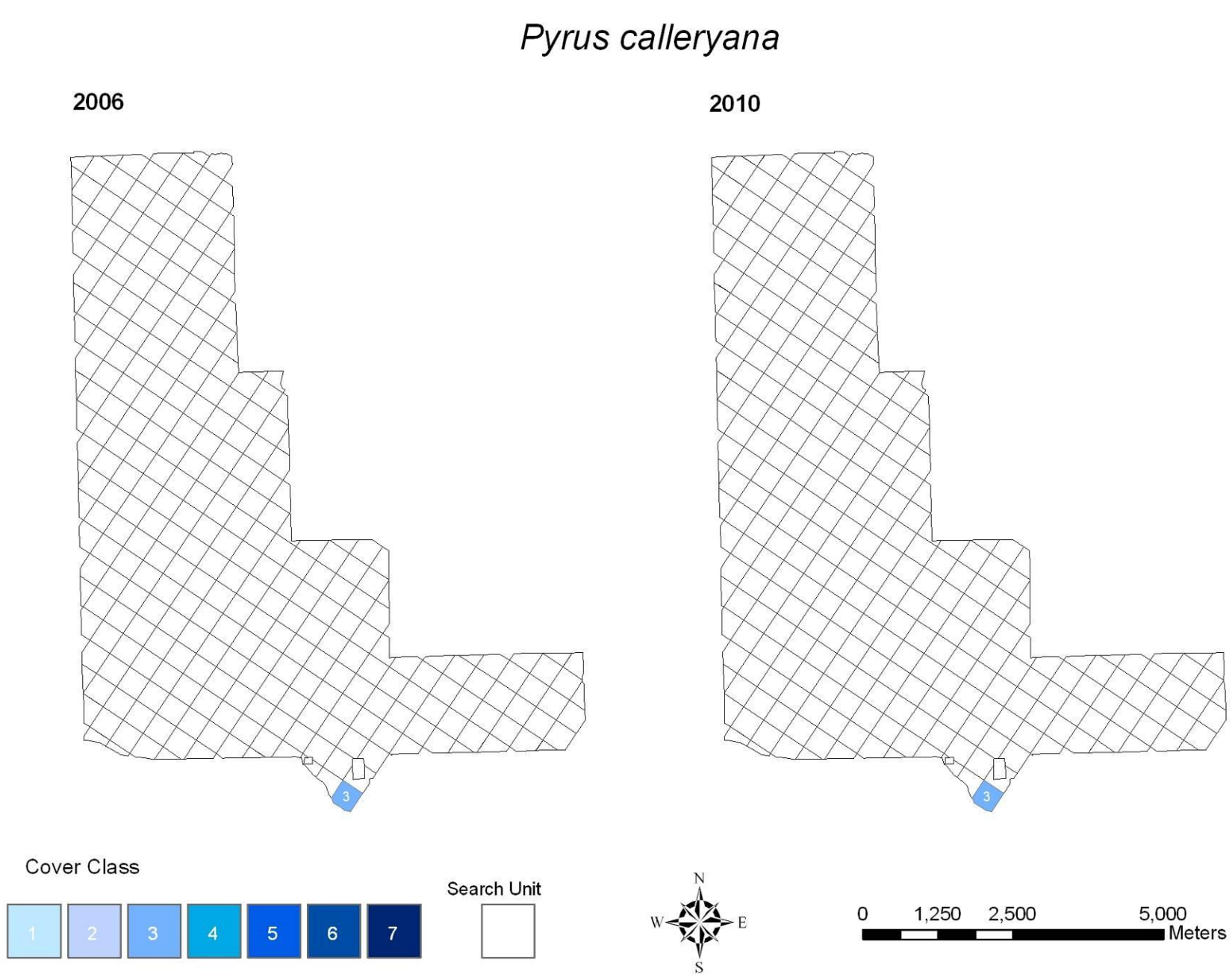

Figure 14. Abundance and distribution of *Pyrus calleryana* (Callery pear) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

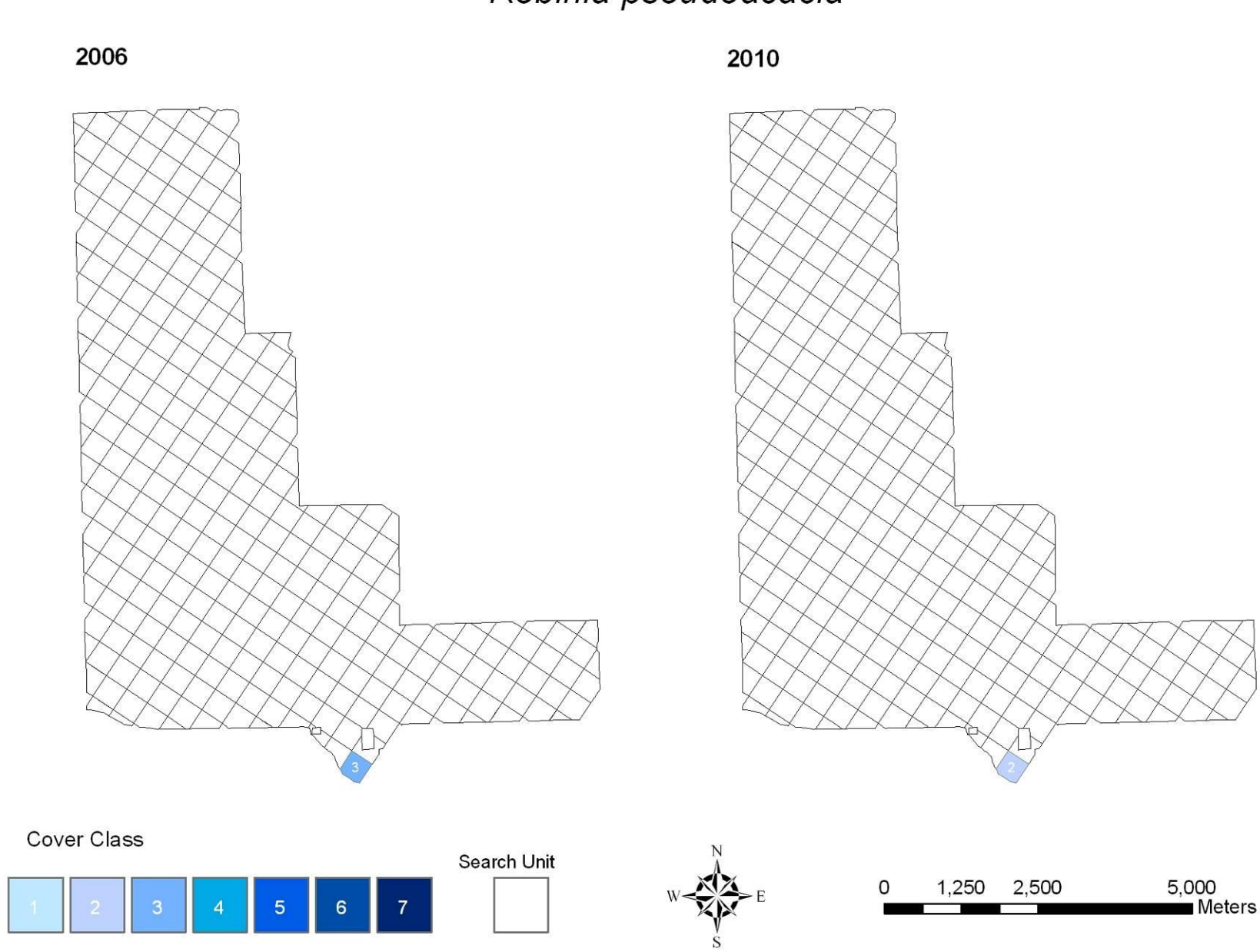

Figure 15. Abundance and distribution of *Robinia pseudoacacia* (black locust) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

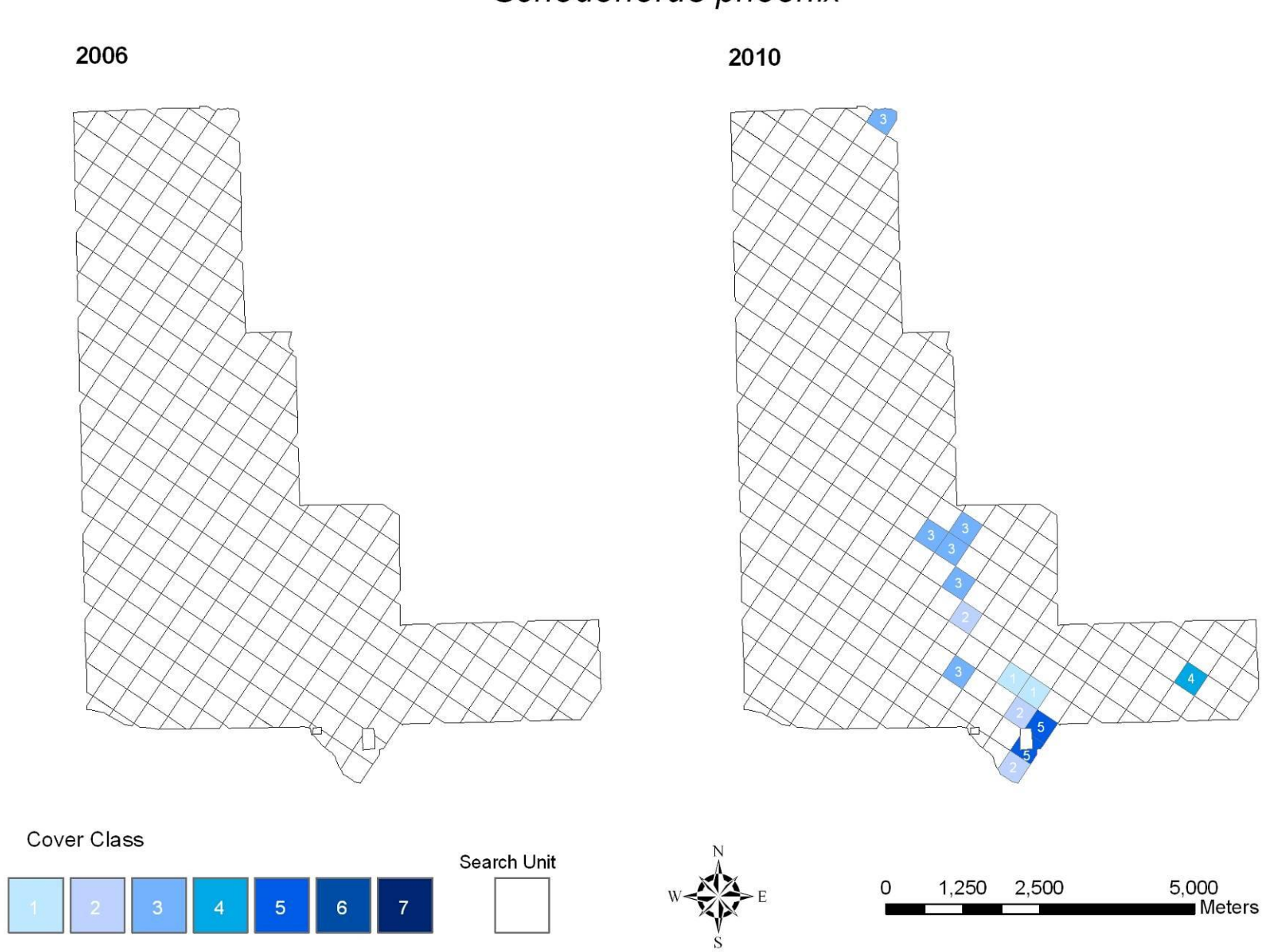

Figure 16. Abundance and distribution of *Scehdonorus* pheonix (tall fescue) at Tallgrass Prairie National Preserve**,** 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

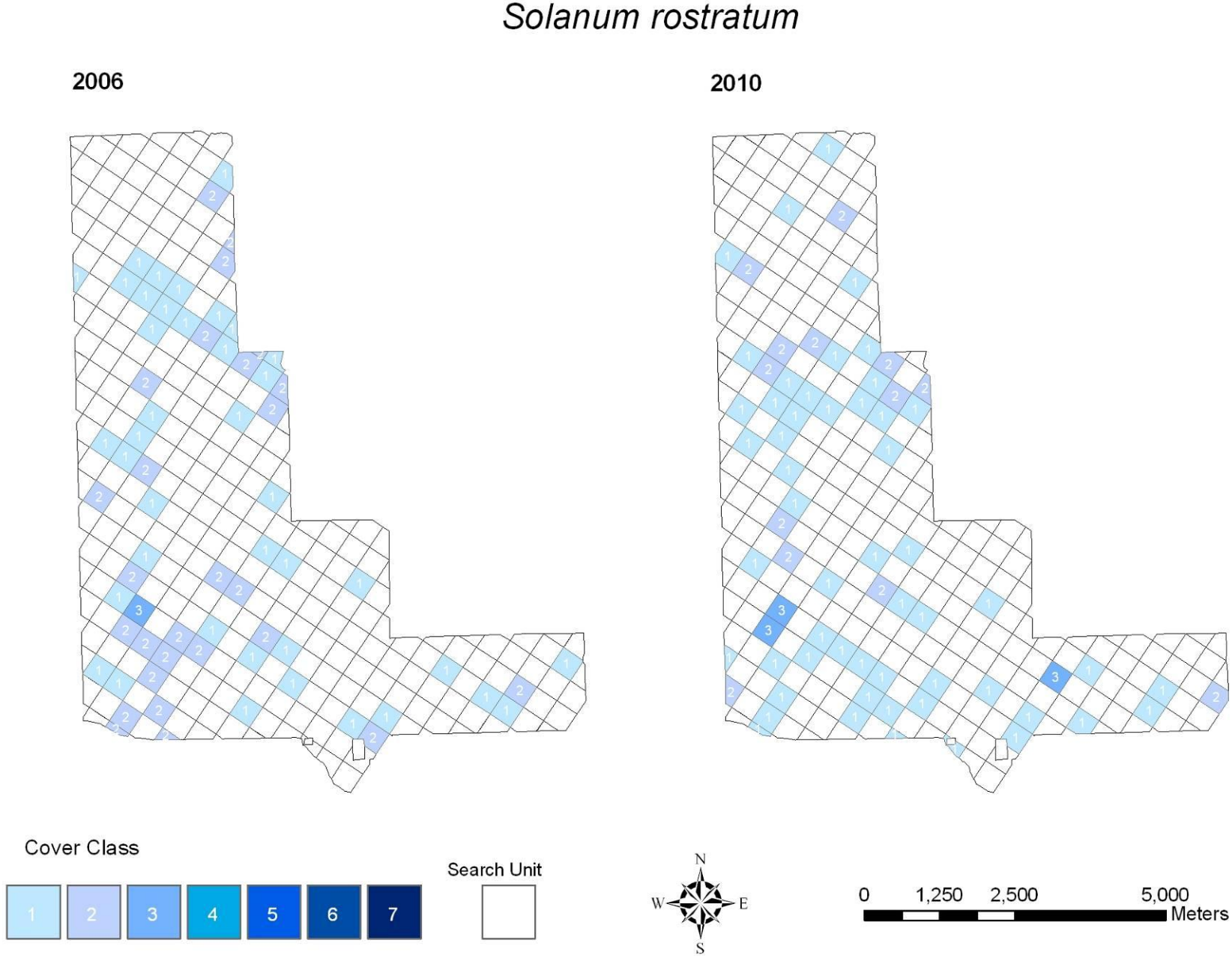

Figure 17. Abundance and distribution of *Solanum rostratum* (buffalobur nightshade) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

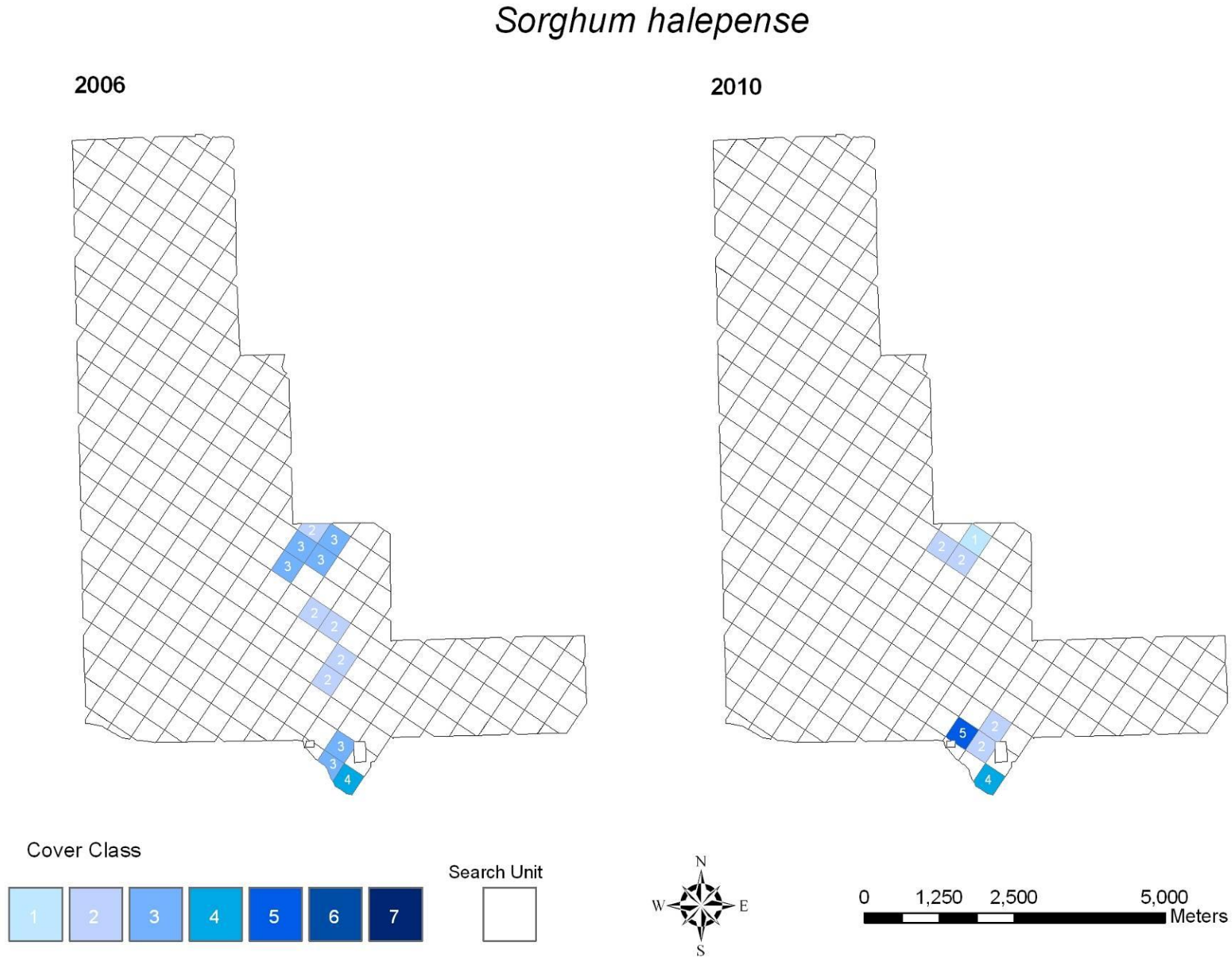

Figure 18. Abundance and distribution of *Sorghum halepense* (Johnsongrass) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

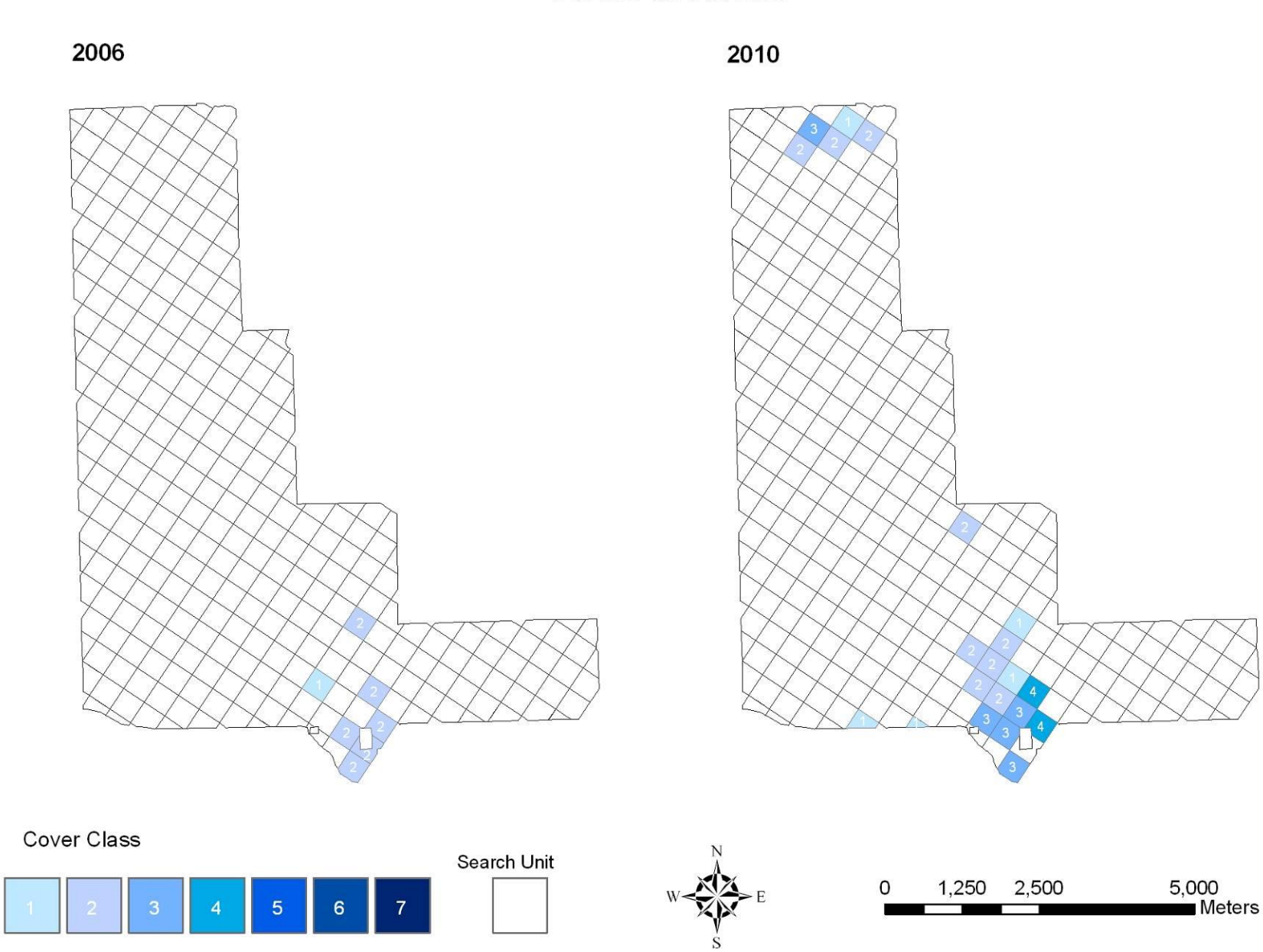

Figure 19. Abundance and distribution of *Torilis arvensis* (spreading hedgeparsley) at Tallgrass Prairie National Preserve, 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

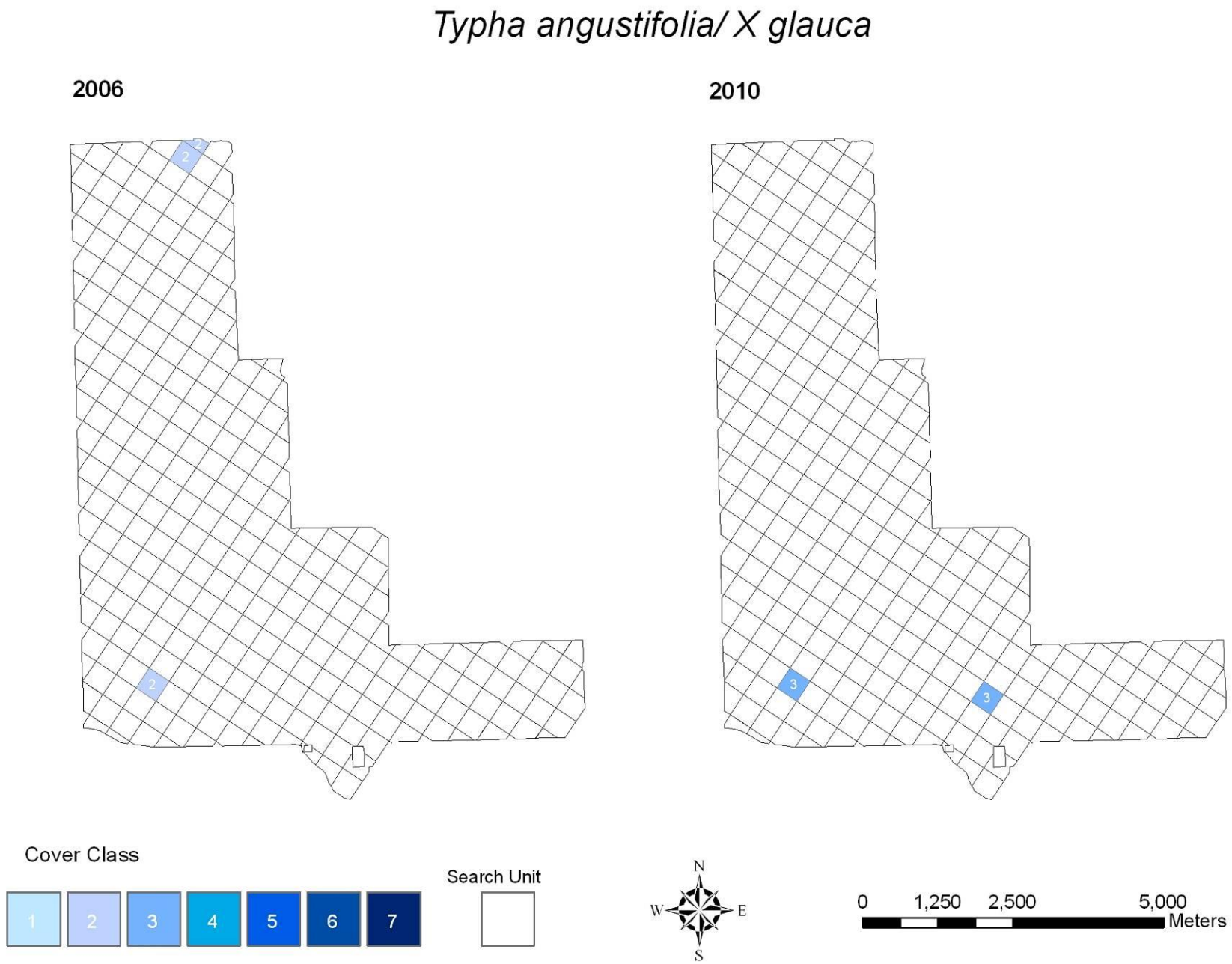

Figure 20. Abundance and distribution of *Typha angustifolia/X glauca* (narrowleaf/hybrid cattail) at Tallgrass Prairie National Preserve**,** 2006 and 2010. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, 7= >1000m^2.

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network
Natural Resource Monitoring

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 372/101349, August 2011

National Park Service
U.S. Department of the Interior

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